

Research on the practical application of TRIZ theory in the cultivation of product design professionals

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Abstract: This paper briefly discusses the important role of TRIZ theory in cultivating innovative talents in product design majors, analyzes the current application of TRIZ theory teaching methods in China, introduces TRIZ theory into the teaching mode of product design studio. And this paper introduces in detail the principles of invention and contradiction matrix, separation principle, the teaching method of the matter-field model, the effective application methods in students' study, practice, competition, participation in enterprise projects and scientific research projects, and the application of TRIZ theory combined with other research methods in teaching is prospected.

Keywords: TRIZ theory, product design, innovative design, design method

1. Introduction

The product design major is an application-oriented major based on the market. At present, our school adopts the studio teaching mode. The studio teaching mode is to introduce enterprises and competition topics into the teaching, and mainly adopts the teaching mode of research guidance. In this mode, students have to participate in a large number of design competitions, and they have to complete the actual enterprise projects they undertake. The work intensity of learning is relatively high. Some students will inevitably fail to keep up with the progress in the process of learning, their thinking is rigid and exhausted, and there is no good idea. point, and gradually lose self-confidence. This requires teachers to use appropriate methods and methods to guide students' ideas, develop students' ideas, and quantify the production of creative thinking. The introduction of TRIZ theory can multiply the creativity of students. The essence of innovative design is To create more valuable new products or services. The product design major of Guilin University of Electronic Science and Technology has won the "Double First-Class" major of national construction in 2020. Many reform attempts have been made in education and teaching methods. Therefore, the author intends to combine the characteristics of product design professional studio teaching and introduce TRIZ theory to improve Students' innovative thinking in the design process.

2. Analysis of the current situation of TRIZ theory teaching application research

TRIZ is an invention problem-solving theory with a complete system proposed by Soviet invention experts Altshuller et al. It provides a large number of problem-solving tools and is a methodology with great influence in modern times. Since the introduction of TRIZ theory into my country, nearly 100 colleges and universities in my country have carried out corresponding TRIZ theory course teaching and practice in different majors. Based on the OBE concept, Jiang Xueyong used TRIZ theory to continuously improve the teaching objectives, teaching methods, educational resources allocation and course evaluation of innovative general courses. This way of combining the requirements of professional training objectives with TRIZ theory is also a good teaching attempt. Liu Xuntao's application project teaching method introduces engineering projects into teaching, gives full play to students' initiative, and conducts discussions and experiments in the form of groups. Then it is recommended to establish a TRIZ theory teaching website to conduct three-dimensional teaching, and at the same time to build a practical training platform inside and outside the school, to carry out course design and graduation design about TRIZ. Yang Jing applied the TRIZ theory to the design of cloth art cultural and creative souvenirs, respectively from three aspects: pattern design, shape design and functional design. These applications have certain reference significance for students when doing cultural and creative design. Zhang Jiaqi and others combined TRIZ theory with iNPD, so that students can do more with less in design. In the CNKI database, there are countless cases based on the application of TRIZ theory in various industries. It can be seen that TRIZ theory is widely used in the field of innovation.

3. Combining TRIZ theory with conventional innovative techniques to expand students' creativity

In the previous teaching of product design methods, he taught the black box method, trial and error method, fishbone diagram, morphological analysis method, 5W2H method, brainstorming method, Osborne checklist method, Hotan twelve method, and improving creativity. These exercises have stimulated the creative thinking of the students to a certain extent, and can effectively improve the students' understanding of what to do, but how to do product design innovation depends on the students' own knowledge level and The application level of innovative techniques, so there is often a certain randomness in the design, and in many cases, it cannot be truly transformed into a specific method for problem solving. Combining with TRIZ theory can effectively solve the problem of how to do in product design, as well as the specific contradictions, especially it adopts a very scientific solution method to convert the problems encountered in product design into general TRIZ To solve the problem, and then seek a standard solution to solve it, as shown in Figure 1.

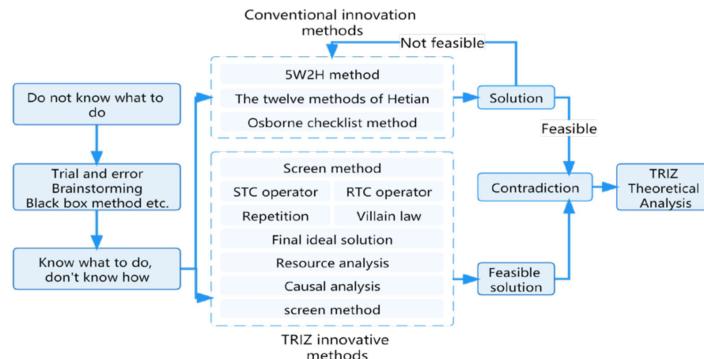


Figure 1 The combined application of TRIZ theory and conventional innovation methods

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4. Taking students as the center to explain the application of 40 invention principles to enhance the subjective initiative of students

In the TRIZ theory system, the 40 principles of invention are relatively easy to grasp, and they are also the most used by students in their studies, so they are also the key content of the lectures, mainly in the following three ways.

4.1 Learning by applying the principles of invention

The principles followed in the lecture are the first specific description of the principles of the invention, the second is to explain the corresponding cases of the description one by one, the third is to introduce the skills of using the principles of the invention, and the fourth is to list some products in life. Conduct classroom discussions to analyze how to apply the principles of invention, and the fifth design practice applies the principles of invention to product innovation design. For example, in the principle of versatility, use the above steps to practice, as shown in Figure 2.

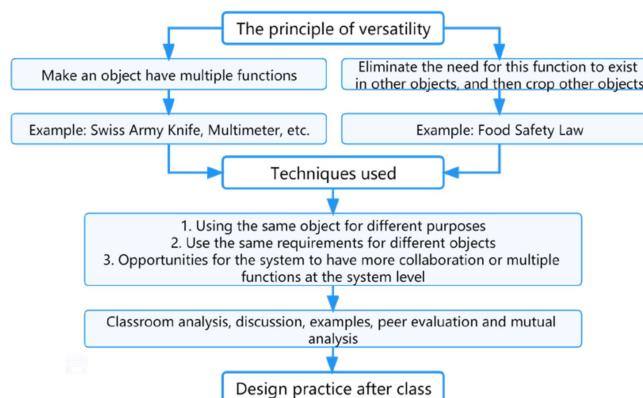


Figure 2 The principle of versatility explains the practical solution

4.2 Summarize and compress the principles of invention and application according to the characteristics of students majoring in product design

Summarize and organize 40 principles of invention, according to the characteristics of strong perceptual thinking of students majoring in product design, according to human vision, hearing, taste, smell, touch or according to human instinct level, behavior level and reflection level, etc. Classify and summarize the corresponding principles for application. This method can help students with weak rational thinking and strong emotional thinking.

4.3 Inductive and applied research on the principles of the invention through a single type of product identified

Conduct research based on a single product, such as special research on lamps, and summarize the corresponding invention principles according to the design requirements of lamps to save space, decorative interest, and multi-functionality. This research method is relatively easy to understand and apply to students who are new to TRIZ theory, and can carry out personalized design according to each student's own preferences, giving full play to each student's subjective initiative. Theories are used to find the corresponding invention principles to design, as shown in table 1.

Table 1 Design requirements of lamps and corresponding TRIZ invention principles

Design Requirements	Corresponding Invention Principles
Space saving	Curved, Nesting, Combination principle, Multi-dimensional
Decorative Interests	Changing colors, Nesting, Dynamization, Adding asymmetry, Using Mediation principles, Porous materials
New Features	Principle of versatility, Principle of reverse thinking, Dynamization, Principle of mechanical vibration, Principle of equipotentiality, Combination method, Principle of state and parameter change, Porous material, Principle of extraction
Safety	Curved, Local mass, Pre-action, Pre-emptive, Flexible shell or membrane structures
Practicality	Division principle, Versatility principle, Weight compensation Principle, Continuity principle of effective action
save costs	Pneumatic or hydraulic structures, By means of intermediaries, Composite materials, Homogeneity, Replacement of mechanical systems, Cheap replacement, Replication principles

Then, according to the corresponding invention principles, the existing products are searched and summarized, as shown in Figure 3.

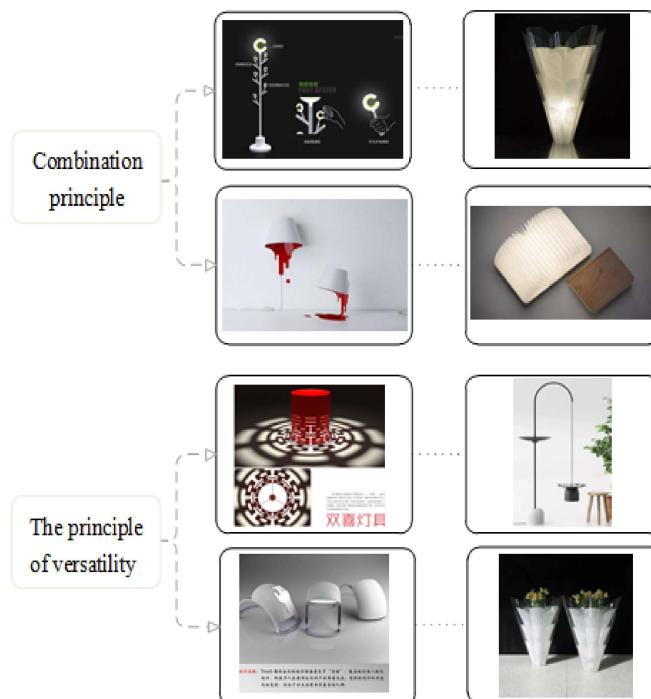


Figure 3 Classification diagram of the principle of the invention of lamps and lanterns

Through the above three steps, teachers' classroom guidance, narrowing down the scope, and personalization can greatly improve the participation of students in the course. From the teacher's teaching to the students' active participation, the learning efficiency is greatly improved, and there are more It is helpful for students to understand the principles of invention.

5. Guide students to solve the contradictions encountered in the design

Lao Tzu said: "Everything bears yin and embraces yang", which means that everything has both positive and negative aspects. "On Contradiction" also wrote: "As far as the order of the movement of human cognition is concerned, it is always gradually expanded from knowing individual and special affairs to knowing general things." To know and solve a problem, you must first be good at knowing Seek, recognize, and discover technical contradictions. When designing products, the purpose is to design products that meet the needs of Party A, and most of these needs are the realization of a certain function or a breakthrough in a certain way of use. When students try to improve a certain function or usage of the product, the performance of other aspects of the product is often affected. At this time, there are internal contradictions within the product. In the process of improving product design, students should constantly solve these contradictions and make their designed products evolve towards the ideal solution. The process of resolving contradictions is a process of solving from a special problem to a general problem, and then from a general problem to a special problem.

5.1 Resolution of technical contradictions in product design

TRIZ theory summarizes problem contradictions into three types: management contradictions, technical contradictions and physical contradictions. Before using the technical contradiction matrix table, it is necessary to convert management contradictions into technical contradictions and then apply them. Technological conflict refers to an effect that leads to both useful and harmful outcomes. Converting specific technical contradictions encountered in product design into corresponding parameters in the 39 contradiction matrix is a process from special to general. This process is difficult, and students need to go through a lot of practice to accurately find the corresponding parameters. Then, corresponding to the contradiction matrix, find the corresponding solution given by the contradiction matrix table. This is a process from general to special. The specific operation process is shown in the figure: To use the contradiction matrix method, it is first necessary to convert the product problem into TRIZ. The expression form is to find out the parameters of improvement and deterioration of product contradictions, then look up the corresponding contradiction matrix table, find the corresponding invention principle, and finally use the invention principle to improve its own design scheme. The design procedure is shown in Figure 4.

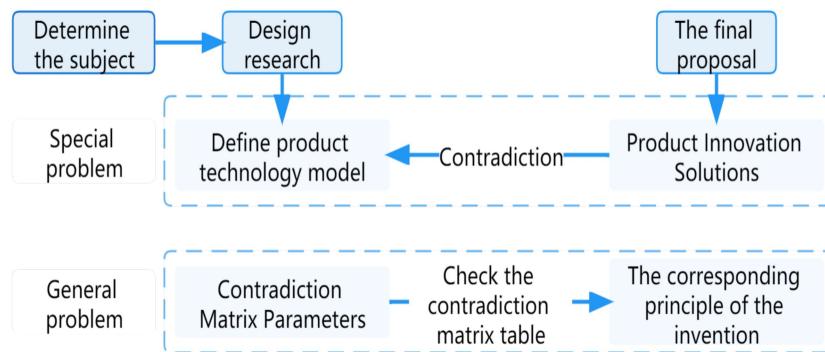


Figure 4 Application of technical contradictions

For example: in the design of isolation beds, first describe the problem: in order to ensure the air quality in the isolation space of patients and reduce the risk of infection for doctors, isolation equipment can be used to isolate the part of the treatment that needs to be treated, but the complexity of isolation equipment It has brought a lot of trouble to the doctor's treatment, that is, using effective facilities to solve the problems caused by simple treatment operations. Secondly, define the product technology model. The easiest way is for doctors to wear protective clothing for infusion therapy. Advantages: fast and simple; Disadvantages: The wearing of protective clothing is complicated and there are potential safety hazards; the contradiction is that simple infusion therapy is required. However, the use of protective clothing is complicated and has hidden dangers. The most reliable way is to use isolation equipment to treat patients without contact. Advantages: safe and effective; Disadvantages: the increase of isolation equipment, the technical operation of a small number of isolation facilities is somewhat complicated; the contradiction is that although the non-contact treatment is carried out Simple treatment operation, but the equipment system is more complex.

Now there are two contradictions: contradiction one: the contradiction between simple non-

contact infusion therapy and the safety of protective clothing. Features that need to be improved: 33# Convenience of operation procedures; Features of system deterioration: 27# Reliability. Paradox 2: The paradox between the security of the added isolation device and the complexity of the device. Characteristics that need to be improved: 13 Object stability; characteristics of system deterioration: 36 # Complexity of the system. Then look up the contradiction matrix table, and design the scheme according to the corresponding invention principle ,as shown in Figure 5 and Figure 6.

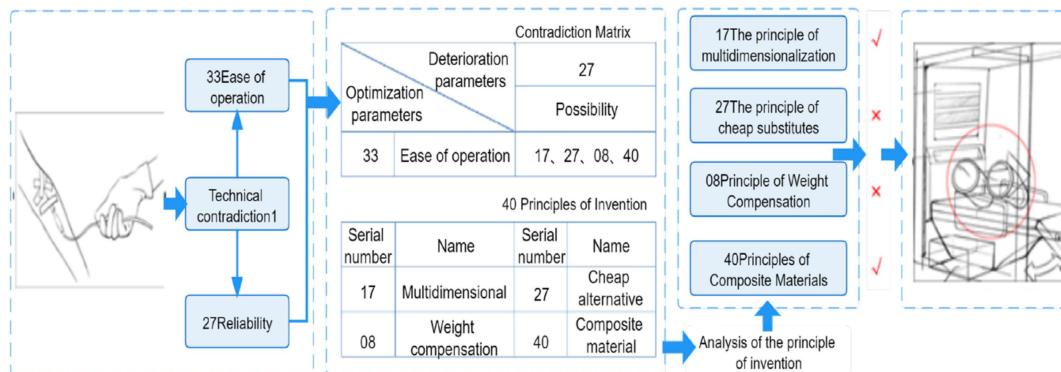


Figure 5 Conflict 1 solution diagram

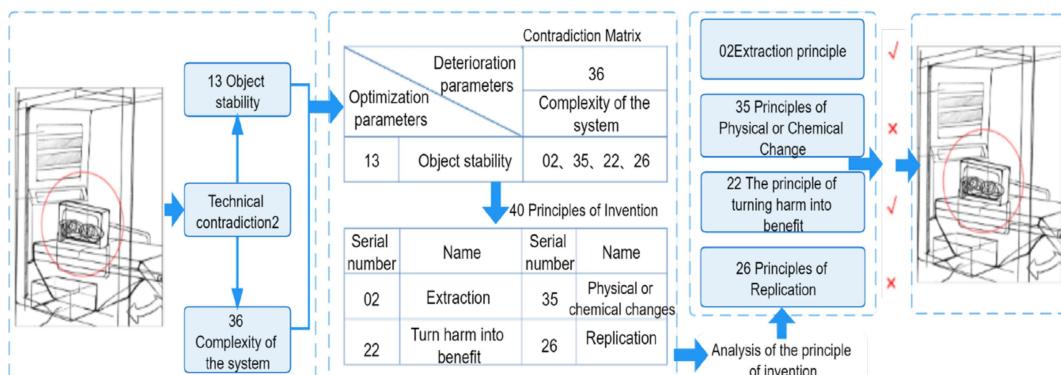


Figure 6 Conflict 2 solution diagram

Based on these innovative principles, it is possible to find the best solution, intelligently design the required treatment parts, use the robotic arm to perform basic treatment measures, free the doctor's hands, and the doctor can remotely operate the patient to treat the patient. Reduced risk of physician infection and air quality assurance in patient isolation spaces.

5.2 Resolution of Physical Contradictions in Product Design

In the process of product design, technical conflicts should be transformed into physical conflicts as much as possible, because physical conflicts are closer to the essence of the problem. Physical contradiction is a contradiction of opposite requirements, an irreconcilable contradiction, and solving the physical contradiction is a difficult point. If you want to solve physical contradictions, you must first determine the contradictions of the plan, and then apply the four principles of separation

according to the contradictions, and the principles of separation correspond to the principles of invention. Therefore, to guide students to solve physical contradictions, you must first choose an appropriate separation principle, and then apply the corresponding invention principle to improve the scheme, as shown in Figure 7.

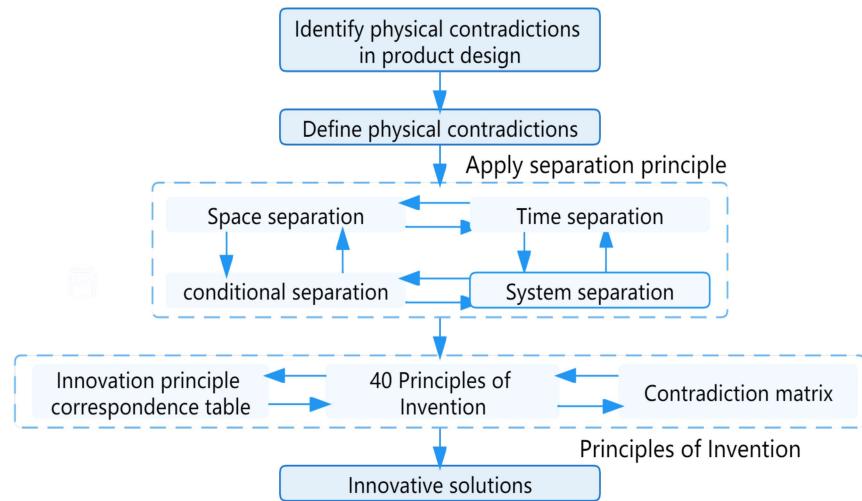


Figure 7 Flow chart of the principle of invention and the principle of separation to solve physical contradictions

For example, in the design of an isolation hospital bed, the problem is to be solved: in order to isolate the space, at the same time, it is necessary to visually expand the feeling of the closed isolation space of the hospital bed, and also to protect the privacy space. At this time, physical contradictions appear. There is a contradiction between the need for a small isolation space and the patient's desire for a large space. In the design, the separation principle is used to separate the part from the whole, as shown in Figure 8. Select the corresponding innovation principle according to the separation principle: 40# composite material, 32# change color. The application of 40# composite material is to use special glass material to make the external shape of the isolation equipment, and the properties of the material are different from those of conventional glass, and the material is transparent inside and outside; the application of changing color of 32# is to use transparent glass material to expand Visual space, widen the field of vision, and visually enlarge the space in which it is located.

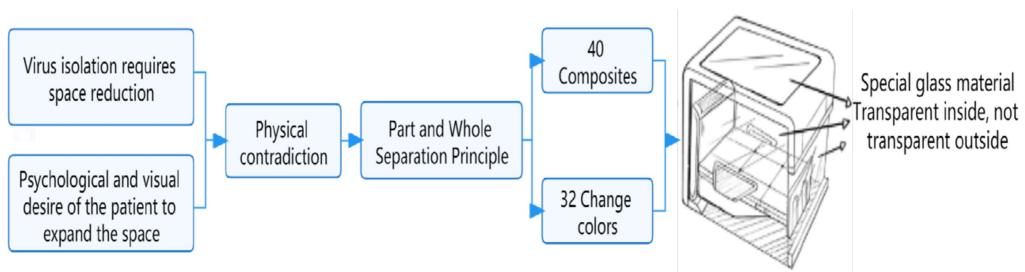


Figure 8 Application diagram of separation principle

6. Solutions to problems with insufficient functionality or excessive damage

In the design, the relationship between objects needs to be dealt with. When the interaction function between objects is excessive or insufficient, it is necessary to use the material-field theory to analyze and solve, and the standard solutions of object field analysis are 76. Therefore, for the students who have just come into contact, it seems a bit complicated, and it is difficult to accurately find the corresponding standard solution. Therefore, it is very important to organize a set of step-by-step steps, so that students can operate and practice according to certain steps, so as to effectively find the standard solution through the object field model, as shown in Figure 9.

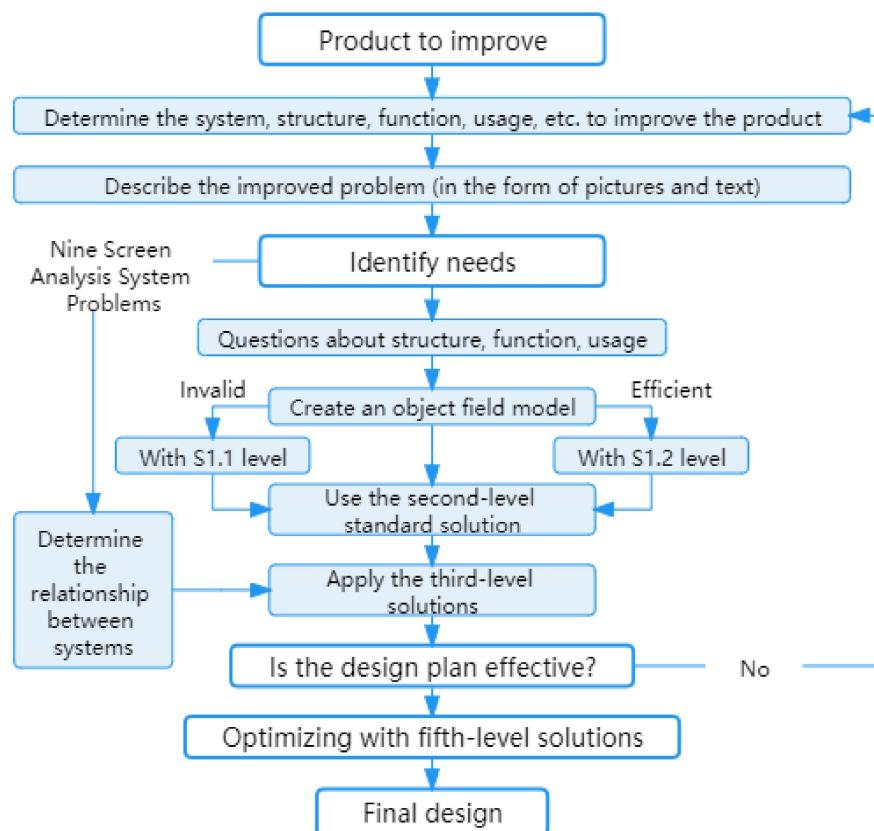


Figure 9 Flowchart of the use of the substance-field model

6.1 First, determine the type of product to be improved, whether it is an innovation in the product service process system, product structure, product function, or use method.

The determination of the type can be carried out according to the following steps:

Analyze the work flow of the product, which can be described in the form of pictures and texts;

Analyze the product system according to the nine-screen method to determine which resources are available;

Analyze the structure and function of the product, and express the interaction between the

elements with the object field model.

6.2 Use 76 standard solutions to improve products

Analyze the object field model established by the product in the first step. If the standard solution is incomplete, analyze the standard solution of the first level and apply it; if the object field model has harmful effects, apply the last five solutions of the first level; If the effect is insufficient for the object field model, the solutions of the second and third levels are applied.

6.3 After determining the standard solutions, check whether these solutions and schemes can be simplified with the 17 standard solutions of the fifth level.

Usually, in the actual design, the object field model should be flexibly applied around the solution to be solved, and the combined application of multiple solutions is of great positive significance for product innovation design.

For example, when designing fire-fighting demolition tools, long-term use or long-distance use will consume a lot of rescue personnel's endurance, and it is necessary to maintain an action for a long time in complex and dangerous environments, which will lead to friction between the hand and the demolition tool. When the force is insufficient and the action is insufficient, consider the problem of analyzing the material-field, that is, a field with insufficient force and instability is formed between the mechanical field, the palm, and the machine handle. Therefore, the S1.1 and third-level solutions are adopted to stabilize the super-system support structure by adding a subsystem between the machine and the palm to the environmental material-field. The angle and length of the support rod can be adjusted without hindering fire rescue. At the same time, the auxiliary demolition tool achieves a stable role, which is suitable for different scenarios and supports the operation of the fire demolition tool, thereby optimizing the solution, as shown in Figure 10.

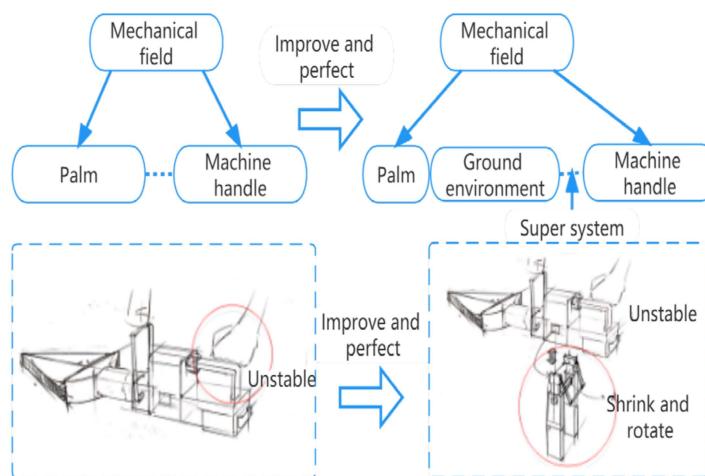


Figure 10 Model diagram of part of the object field of fire-fighting demolition tools

7. Establish an innovative design platform and use TRIZ theory to innovate product solutions

Innovative problem-solving is the essence of TRIZ theory. Through creativity and creation, TRIZ theory has produced a series of solutions and patented achievements. The next step is the application of these achievements and their effect in actual production and life, that is, innovation.

In the process of design practice, the design process of "innovative design strategy-innovative design method-innovative design scheme" is used to carry out the process of product innovation design platform according to specific design requirements ,as shown in Figure 11.

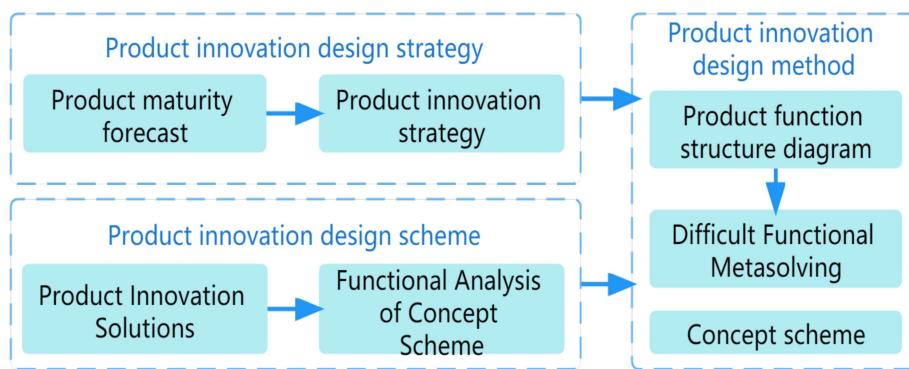


Figure 11 Process of innovative design platform

Students choose innovative design strategies:especially in the design process of horizontal projects, first of all, you can use the product technology maturity prediction system to predict the maturity of the designed products, and choose innovative strategies according to the results. Then, according to the life cycle of the product, choose the corresponding sustainable innovation strategy, breakthrough innovation strategy or disruptive innovation strategy.

In the design process, the students apply innovative design methods:first, draw the functional structure diagram of the product, find out the technical defects or problems of the difficult functional elements, and then solve the technical contradictions according to the TRIZ theory.

Finally design an innovative plan:analyze the conceptual plan according to the process of "function-behavior-structure", match the plan in the plan according to the analysis result, and then generate an innovative plan.

8. Conclusion

By introducing TRIZ theory into the teaching of product design majors, the specific operability and practicality of product design methods are greatly enhanced, which can effectively guide students in the direction of learning. Most students can accept the integration of TRIZ theory and traditional design methods. Teaching, and in the early stage of design, it has greatly helped to break the stereotype and expand the design creativity of students. Completing the final design more reasonably.

As a product design teacher, in addition to introducing the basic TRIZ theoretical knowledge to the students to integrate with traditional design methods, they should also pay attention to the latest research methods on TRIZ theory at home and abroad, such as by combining TRIZ with other theories such as DFSS and QFD. Integrated method, using the combination of patent analysis and TRIZ theory to conduct product forecasting research, combining extenics and TRIZ theory for product creative output, research based on the combination of KANO model and TRIZ contradiction matrix method , using the DCC theory and the material-field model in TRIZ to combine research, using 76 standard solutions to reduce the complexity of the system and realize product redesign and other methods, these methods are combined with the overall TRIZ theory, and some Combined with some of the contents of the TRIZ theory, through the application and research of these new methods, these new methods and new applications are applied to teaching in a timely manner. In the future TRIZ theoretical system, there will be a variety of other theories and ideas that are integrated and applied together.

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